

WYOMING GAME AND FISH DEPARTMENT

FISH DIVISION

ADMINISTRATIVE REPORT

TITLE: Instream Flow Studies on Salt Creek (tributary to Thomas Fork River)
a Bonneville Cutthroat Trout (*Oncorhynchus clarki utah*) Stream.

PROJECT: IF-PE96-07-9503

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ABSTRACT

Instream flow data were collected in 1995 on Salt Creek to determine flows needed to maintain or improve Bonneville cutthroat trout (BRC) habitat and populations. Studies were designed to complement ongoing monitoring of BRC index streams (Remmick et al. 1994).

Physical Habitat Simulation (PHABSIM), the Habitat Quality Index (HQI), and the Habitat Retention Method were used to derive instream flow recommendations. Recommendations are: October 1 - April 14 = 4.4 cfs, April 15 - June 30 = 14.0 cfs, and July 1 - September 30 = 5.2 cfs.

INTRODUCTION

Wyoming Bonneville cutthroat trout (*Oncorhynchus clarki utah*) populations occur primarily in the Thomas Fork and Smiths Fork watersheds. Physical, chemical, and biological characteristics were inventoried between 1966 and 1977 (Miller 1977). Binns (1981) reviewed the distribution, genetic purity, and habitat conditions for Bonneville cutthroat trout populations. Recent population and habitat survey results are in Remmick (1981, 1987) and Remmick et al. (1994). In general, populations are limited by seasonally low flows, lack of riparian cover, thermal pollution arising in conjunction with low flows and reduced riparian vegetation, and silt pollution (Binns 1981).

Bonneville Cutthroat trout were recently petitioned for listing under the Endangered Species Act but are not listed at this time. Status review was initiated in response to concerns expressed by the Idaho Fish and Game Department, the Desert Fishes Council and the Utah Wilderness Association. This species is considered "rare" by the Wyoming Game and Fish Department (WGFD 1977).

A 5-year management plan for Wyoming, developed by the Wyoming Game and Fish Department (WGFD) in coordination with the U.S. Forest Service (USFS) and U.S. Bureau of Land Management (BLM), outlines management goals and provides criteria for listing Bonneville cutthroat trout as threatened (Remmick et al. 1994). The plan's purpose is to outline management practices to prevent listing by moving toward wider

distribution and higher populations. The plan recommends that status decisions be made after five-years of population and habitat monitoring. Habitat protection by acquiring instream flow water rights will not directly achieve the plan's goals but rather serve to prevent additional population declines.

Fish and other resource management practices could be significantly affected by listing Bonneville cutthroat trout as Threatened or Endangered. Instream flow water right identification and acquisition on -Bonneville cutthroat trout streams is important to help avoid listing. Therefore, the WGFD filed for water rights on Huff Creek, Coal (Howland) Creek, Hobble Creek, Porcupine Creek, Smiths Fork River, and Raymond Creek in 1993 and 1994. Studies in 1995 focused on Salt Creek, Coal Creek, Giraffe Creek, Water Canyon Creek, and Coantag Creek.

Study objectives were to 1) investigate the relationship between discharge and physical habitat quantity and quality for Bonneville cutthroat trout and, 2) determine an instream flow necessary to maintain or improve Bonneville cutthroat trout populations.

METHODS

Study Area

Salt Creek is a tributary to the Thomas Fork River (Figure 1). The upper basin (above 6522 ft) is managed by the Bridger-Teton National Forest (BTNF) and downstream of the Forest the stream flows through state and private land along highway 89. Livestock grazing occurs throughout the watershed. Sagebrush/grass communities predominate at lower to middle elevations with mixed aspen and conifers at higher elevations and hillside valleys. Willow are scattered in the riparian zone. Overall stream gradient is moderate (<2.5 %) and the channel type was rated as C1 (Rosgen 1985). This rating indicates a moderately entrenched channel that is moderately confined by its valley and has bed material composed of large cobble, course gravel, and sand.

Habitat improvement work on state land consisting of check dams, log revetments, and riprap was completed in August 1990. Additional habitat improvement work has been completed upstream on the BTNF.

Fisheries

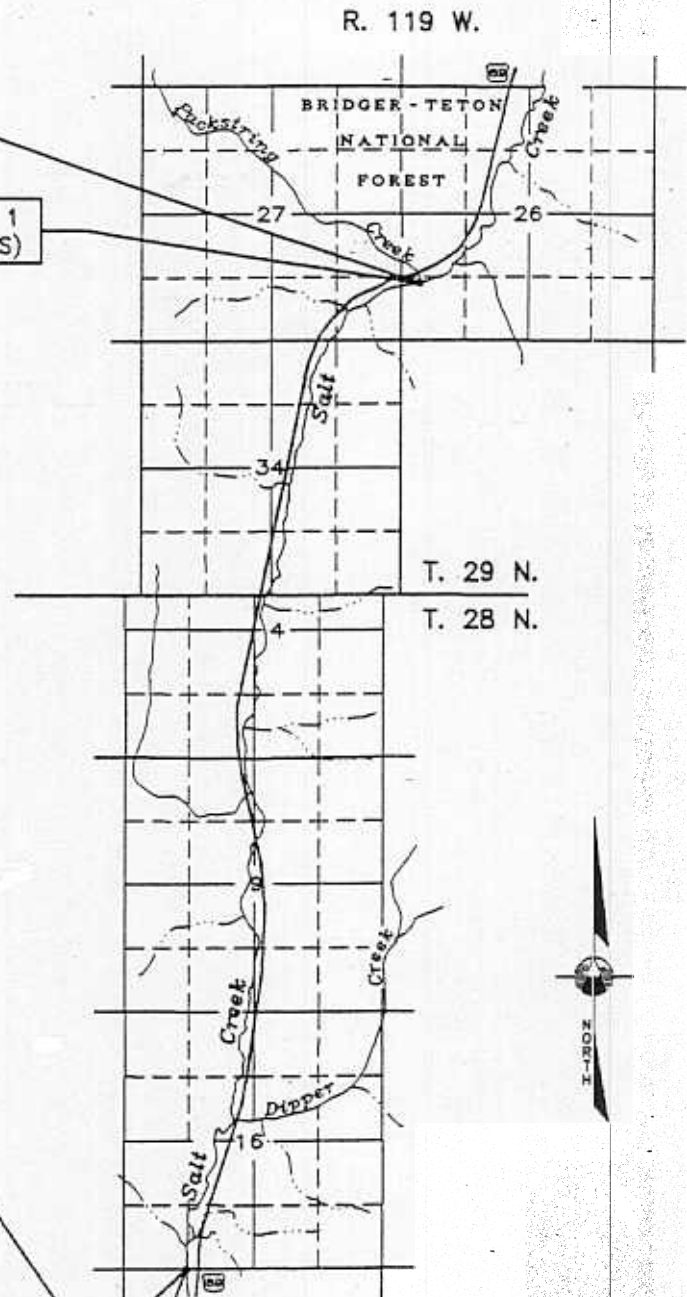
Trout populations, particularly in small mountain streams, normally fluctuate widely. It is not unusual for pristine streams to contain different trout numbers among consecutive years. In a western Oregon stream studied for 11 years, density of age 0 cutthroat trout (fry, <2 inches) varied from 8 to 38 per 100 m² and density of age 1 cutthroat trout (juveniles, 4-4.5 inches) ranged from 16 to 34 per 100 m² (House 1995). In this example, population fluctuations occurred despite the fact that habitat conditions were not degraded and appeared to be relatively stable. The author suggested that small changes in peak winter flows between years would have accounted for shifts in overwinter survival between age-classes.

In western Wyoming, Binns (1981) noted significant trout number declines in several Bonneville cutthroat trout streams, including Salt Creek, following drought in 1977. Salt Creek data collected periodically throughout the last 20 years further illustrate annual variation. Number per mile at two state land stations varied between 201 and 669 (1979 and 1974, respectively). These numbers demonstrate the inherent population size variability of Salt Creek.

INSTREAM FLOW SEGMENT NO. 1 - POINT OF BEGINNING
Confluence with Packstring Creek in SW 1/4,
SW 1/4, Section 26, T.29 N., R.119 W.

SALT CREEK INSTREAM FLOW SEGMENT NO. 1
(LENGTH OF STREAM SEGMENT = 4.5 MILES)

INSTREAM FLOW SEGMENT NO. 1 - POINT OF ENDING
South Boundary of SW 1/4, SW 1/4,
Section 16, T.28 N., R.119 W.



Long-term trout population maintenance in small streams depends on periodic strong year classes produced in good flow years. Without benefit of periodic favorable flows, populations in some streams would decline or disappear. The WGFD instream flow strategy recognizes the inherent variability of trout populations as documented in Salt Creek and other streams (House 1995) and thus defines the "existing fishery" as a dynamic feature. Instream flow recommendations are based on a goal of maintaining habitat conditions that provide the opportunity for trout numbers to fluctuate within existing natural levels.

Habitat Modeling

After visually surveying the stream from its confluence with Coal Creek upstream to where it becomes Water Canyon Creek (approximately 9.0 miles, a study site was located on state land upstream from Dipper Creek in Township 28N, Range 119W, Section 9, NW1/4 (Figure 1). The representative site had trout cover associated mostly with habitat improvement structures (log revetments) in pools. Nine consecutive transects were distributed among pool, run, and riffle habitat types (Appendix 1).

Data were collected between May 12 and August 25, 1995 (Table 1). Instream flow filing recommendations derived from this site were applied to an approximately 4.5 mile-long reach extending downstream from the confluence of Packstring Creek in section 26 in T29N, R119W to the southern boundary of section 16 in T28N, R119W. The land through which the proposed segment passes is under Bridger-Teton National Forest and state administration. In addition, approximately 1/2 mile of the proposed segment passes through privately owned land.

Table 1 Dates and discharges Salt Creek instream flow data were collected in 1995.

| Date | Discharge (cfs) |
|-----------|-----------------|
| May 12 | 108.0 |
| June 29 | 26.9 |
| August 25 | 7.4 |

Determining critical trout life stages (fry, juvenile, adult, etc.) during specific time frames aids in focusing flow recommendations. Critical life stages are those most sensitive to environmental stresses. Annual population integrity is sustained by providing adequate flow for critical life stages. In many cases, trout populations are constrained by spawning and young (fry and juvenile) life stage habitat "bottlenecks" (Nehring and Anderson 1993). Therefore, our general approach includes ensuring that adequate flows are provided to maintain spawning habitat in the spring as well as adult and juvenile habitat throughout the remainder of the year. (Table 2).

Table 2 Bonneville cutthroat trout life stages and months considered in Salt Creek instream flow recommendations. Numbers indicate method used to determine flow requirements.

| LIFE STAGE | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC |
|------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| SPAWNING | | | | | | | 1 | 1 | 1 | | | |
| ADULT | | | | | 2 | 2 | | | | | | |
| ALL | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |

1 - Habitat Quality Index

2 - PHABSIM

3 - Habitat Retention

Habitat Retention Method

A Habitat Retention method (Nehring 1979, Annear and Conder 1984) was used to identify a maintenance flow by analyzing data from three riffle transects. A maintenance flow is defined as the continuous flow required to maintain specific hydraulic criteria in stream riffles. Year-round criteria maintenance ensures passage between habitat types for all trout life stages. In addition, the criteria maintain adequate benthic invertebrate survival. A maintenance flow is realized at the discharge for which any two of the three criteria in Table 3 are met for all riffle transects in a study area. The instream flow recommendations from the Habitat Retention method are applicable year round except when higher instream flows are required to meet other fishery management purposes (Table 2).

Table 3 Hydraulic criteria for determining maintenance flow with the Habitat Retention method.

| Category | Criteria |
|---------------------------------------|-------------------------------|
| Mean Depth (feet) | Top Width ^a X 0.01 |
| Mean Velocity (feet/second) | 1.00 |
| Percent Wetted Perimeter ^b | 50 |

a - At average daily flow. Minimum depth = 0.20

b - Percent of bank full wetted perimeter

Habitat Quality Index

The Habitat Quality Index (HQI; Binns and Eisermann 1979) was used to estimate trout production over a range of late summer flow conditions. This model was developed by the WGFD and received extensive testing and refinement. It has been reliably used in Wyoming for trout standing stock gain or loss assessment associated with instream flow regime changes. The HQI model includes nine attributes addressing biological, chemical, and physical aspects of trout habitat. Results are expressed in trout Habitat Units (HUs), where one HU is defined as the amount of habitat quality that will support about 1 pound of trout. HQI results were used to identify the flow needed to maintain or improve existing levels of Bonneville cutthroat trout production between July 1 and September 30 (Table 2).

In the HQI analysis, habitat attributes measured at various flow events are assumed to be typical of mean late summer flow conditions. Under this assumption, HU estimates are extrapolated through a range of potential late summer flows (Conder

and Annear 1987). Salt Creek habitat attributes were measured on the same dates PHABSIM data were collected (Table 1). Some attributes were mathematically derived to establish the relationship between discharge and trout production at discharges other than those measured. Average daily flow (ADF; 19 cfs) was estimated from elevation and basin area (Lowham 1976) and average peak flow (156 cfs) was estimated from basin area and peak flow at Thomas Fork gage 10041000.

Physical Habitat Simulation

Physical Habitat Simulation (PHABSIM) methodology was used to quantify physical habitat (depth and velocity) availability over a range of discharges. This methodology was developed by the Instream Flow Service Group of the U.S. Fish and Wildlife Service (Bovee and Milhous 1978) and is widely used for assessing instream flow relationships between fish and physical habitat (Reiser et al. 1989).

The PHABSIM method uses empirical relationships between physical variables (depth, velocity, and substrate) and suitability for fish to derive weighted usable area (WUA; suitable ft^2 per 1000 ft of stream length) at various flows. Depth, velocity, and substrate were measured along transects (*sensu* Bovee and Milhous 1978) on the dates in Table 1. Hydraulic calibration techniques and modeling options in Milhous et al. (1984) and Milhous et al. (1989) were employed to incrementally estimate physical habitat between 1 and 125 cfs. Precision declines outside this range; however, the modeled range accommodates typical Salt Creek flows.

Curves describing depth, velocity and substrate suitability for trout life stages are a vital component of the PHABSIM modeling process. Suitability curves are listed in Appendix 2.

Estimates by Binns (1981) indicate BRC spawning activity in Salt Creek (elevation 6360-6600 feet) peaks approximately between May 2 and May 20. In 1994, spawning fish were observed on May 12. Because spawning onset and duration varies between years due to differences in flow quantity and water temperature, spawning recommendations should extend from April 15 to June 30. Even if spawning is completed by June 1, maintaining flows at a selected level throughout June will benefit trout egg incubation by preventing dewatering. The PHABSIM model was used to obtain flow recommendations for maintaining or improving BRC spawning habitat from April 15 to June 30 (Table 2).

RESULTS AND DISCUSSION

Habitat Retention Analysis

Habitat retention analysis indicates that 4.4 cfs is required to maintain hydraulic criteria at all riffles to provide passage between habitats for all trout life stages (Table 4). Maintenance of naturally occurring flows up to this flow is necessary at all times of the year. Higher flows are needed April 15th through June 30 to support critical life stages (Table 2).

Table 4 Simulated hydraulic criteria for three Salt Creek riffles Average daily flow = 19.0 cfs. Bank full discharge = 123 cfs.

| | Mean Depth (ft) | Mean Velocity (ft/s) | Wetted Perimeter (ft) | Discharge (cfs) |
|----------|-------------------|----------------------|-----------------------|------------------|
| Riffle 1 | 1.09 | 3.88 | 30.1 | 123.0 |
| | 1.04 | 3.76 | 28.6 | 108.0 |
| | 1.00 | 3.34 | 21.9 | 70.0 |
| | 0.86 | 2.56 | 16.4 | 35.0 |
| | 0.77 | 2.21 | 15.0 ^a | 24.6 |
| | 0.71 | 1.98 | 14.0 | 19.0 |
| | 0.47 | 1.33 | 12.2 | 7.4 |
| | 0.30 | 1.00 ^a | 11.4 | 3.4 ^b |
| | 0.21 | 0.86 | 11.0 | 2.0 |
| | 0.20 ^a | 0.83 | 10.5 | 1.7 |
| Riffle 2 | 1.44 | 3.48 | 25.4 | 123.0 |
| | 1.38 | 3.34 | 24.3 | 108.0 |
| | 1.23 | 2.91 | 20.3 | 70.0 |
| | 1.01 | 2.24 | 16.0 | 35.0 |
| | 0.89 | 1.94 | 14.8 | 24.6 |
| | 0.78 | 1.76 | 14.3 | 19.0 |
| | 0.50 | 1.21 | 12.7 ^a | 7.6 |
| | 0.38 | 1.00 ^a | 11.8 | 4.4 ^b |
| | 0.27 | 0.81 | 9.5 | 2.0 |
| | 0.20 ^a | 0.67 | 7.8 | 1.0 |
| Riffle 3 | 1.35 | 3.74 | 25.2 | 123.0 |
| | 1.29 | 3.57 | 24.2 | 108.0 |
| | 1.04 | 3.07 | 22.6 | 70.0 |
| | 0.75 | 2.43 | 19.8 | 35.0 |
| | 0.61 | 2.58 | 17.5 | 26.9 |
| | 0.51 | 2.25 | 16.9 | 19.0 |
| | 0.31 | 1.61 | 15.9 | 8.0 |
| | 0.20 ^a | 1.23 | 15.4 | 3.8 |
| | 0.12 | 1.00 ^a | 14.7 | 1.8 ^b |
| | <0.09 | <0.87 | <12.8 ^a | <1.0 |

a - Hydraulic criteria met

b - Discharge at which 2 of 3 hydraulic criteria are met

Based on habitat retention results, an instream flow of 4.4 cfs is recommended for the October 1 to April 14 time period. If approved, this flow level will maintain the existing fishery because it protects existing natural flow patterns up to the identified maintenance level. Trout populations are naturally limited by low flow conditions during the winter months (October through March; Needham et al. 1945, Reimers 1957, Butler 1979, Kurtz 1980, Cunjak 1988). Such factors as snow fall, cold intensity, and duration of cold periods can influence winter trout survival. Fish populations are influenced primarily through the effects of frazil ice including metabolic stress and anchor ice formation which limits habitat and may result in stranding.

These winter mortality causes are all influenced by winter flows. Higher flows minimize temperature changes and increase stream areas where trout can escape frazil ice impacts. Any artificial reduction of natural winter stream flows would increase trout mortality and effectively reduce the number of fish the stream could support. Therefore protection of natural winter stream flows up to the recommended maintenance flow is necessary to maintain existing survival rates of trout populations.

The 4.4 cfs identified by the Habitat Retention Method may not always be present during the winter. Because the existing fishery is adapted to natural flow patterns (see above fisheries discussion), occasional periods of natural shortfall during the winter do not imply a need for additional storage. Instead, they illustrate the necessity of maintaining all natural winter stream flows, up to 4.4 cfs, to maintain existing trout survival rates.

Habitat Unit Analysis

Article 10, Section d of the Instream Flow Act states that waters used for providing instream flows "shall be the minimum flow necessary to maintain or improve existing fisheries". Often, HU's measured during low flow are used to define the existing late summer fisheries. In situations where the goal is to "maintain" existing fisheries, we determine the flow range with the same HU's as measured and the minimum flow in that range becomes the recommendation. At the measured late summer flow of 7.4 cfs, HQI analysis indicates approximately 53.6 trout HUs (Figure 2). This level of habitat is maintained between 5.2 and 7.5 cfs. Therefore, the minimum flow to maintain the fishery during late summer is 5.2 cfs. Maintaining higher late summer flows would increase habitat.

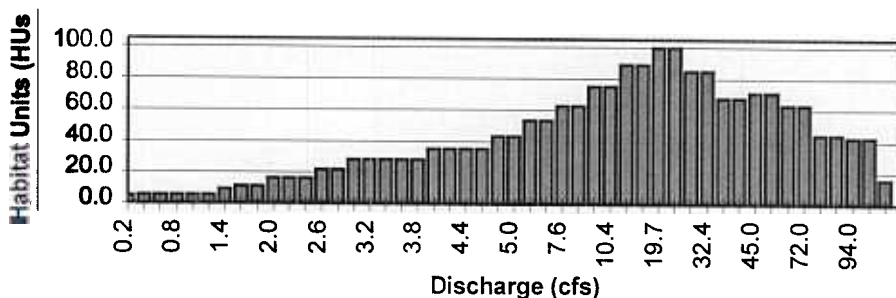


Figure 2. Trout habitat units at several late summer Salt Creek flow levels X-axis discharges are not to scale.

Based on HQI analysis and in consideration of the Bonneville cutthroat trout Management Plan's goals (Remmick et al. 1994), an instream flow of 5.2 cfs is recommended to maintain existing trout production between July 1 and September 30. This flow represents the lowest stream flow that will accomplish this objective. Storage to achieve this flow solely for instream flow purposes is likely not in the State's best interest.

PHABSIM Analyses

Weighted usable area estimates for Bonneville cutthroat trout are in Figure 3. Adult and juvenile physical habitat peak at about 6.5 and 2.5 cfs, respectively. The 5.2 cfs late-summer flow and the 4.4 cfs maintenance flow will maintain over 85% of maximum WUA for both the adult and juvenile life stages.

Spawning was identified as a critical life stage. Peak spawning physical habitat occurs at 14.0 cfs. Normal spring flows are much higher - 108 cfs was measured in this study (Table 1). Such high flows might limit spawning activity near the study site or cause migration to more favorable (upper) reaches. Though trout can usually find someplace to spawn whenever temperatures are appropriate and flows allow unrestricted movement, maximum physical habitat in the study site occurs at a flow of 14.0 cfs. Therefore, an instream flow of 14.0 cfs is recommended for the period May 1 to June 30.

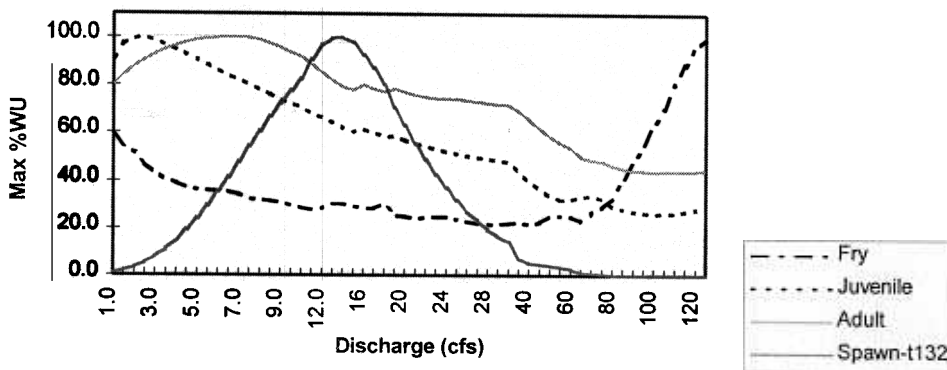


Figure 3. Weighted usable area (percent of maximum) for Bonneville Cutthroat trout life stages in Salt Creek over a range of discharges.

INSTREAM FLOW RECOMMENDATIONS

Based on the analyses and results outlined above, the instream flow recommendations in Table 5 will maintain the existing Salt Creek Bonneville cutthroat trout fishery. These recommendations apply to 4.5 mile segment of Salt Creek extending downstream from the confluence of Packstring Creek in section 26 in T29N, R119W to the southern boundary of section 16 in T28N, R119W. Because data were collected from representative habitats and simulated over a wide flow range, additional data collection under different flow conditions would not significantly change these recommendations.

Table 5. Instream flow recommendations to maintain or improve the existing Salt Creek trout fishery.

| Time Period | Instream Flow Recommendation (cfs) |
|------------------------|---------------------------------------|
| April 15 to June 30 | 14.0 |
| July 1 to September 30 | 5.2 |
| October 1 to April 14 | 4.4 |

This analysis does not consider periodic requirements for channel maintenance flows. Because this stream is unregulated, channel maintenance flow needs are adequately met by natural runoff patterns. If regulated in the future, additional studies and recommendations may be appropriate for establishing channel maintenance flow requirements.

LITERATURE CITED

- Annear, T.C. and A.L. Conder. 1984. Relative bias of several fisheries instream flow methods. North American Journal of Fisheries Management 4:531-539.
- Binns, N.A. 1981. Bonneville cutthroat trout *Salmo clarki* utah in Wyoming Wyoming Game and Fish Department, Fisheries Technical Bulletin No. 5.
- Binns, N.A. and F. Eiserman. 1979. Quantification of fluvial trout habitat in Wyoming. Transactions of the American Fisheries Society 108:215-228.
- Bovee, K. and R. Milhous. 1978. Hydraulic simulation in instream flow studies: theory and technique. Instream Flow Information Paper 5, FWS/OBS-78/33, Cooperative Instream Flow Service Group, U.S. Fish and Wildlife Service. Fort Collins, Colorado.
- Bozek, M.A. and F.J. Rahel. 1992. Generality of microhabitat suitability models of young Colorado River Cutthroat trout (*Oncorhynchus clarki pleuriticus*) across site and among years in Wyoming streams. Canadian Journal of Fisheries and Aquatic Science 49:552-564.
- Butler, R. 1979. Anchor ice, its formation and effects on aquatic life. Science in Agriculture, Vol XXVI, Number 2, Winter, 1979.
- Conder, A.L. and T.C. Annear. 1987. Test of weighted usable area estimates derived from a PHABSIM model for instream flow studies on trout streams North American Journal of Fisheries Management 7:339-350.
- Cunjak, R.A. 1988. Physiological consequences of overwintering in streams; the cost of acclimatization? Canadian Journal of Fisheries and Aquatic Sciences 45:443-452.
- House, R. 1995. Temporal variation in abundance of an isolated population of cutthroat trout in western Oregon, 1981-1991. North American Journal of Fisheries Management 15:33-41.
- Kurtz, J. 1980. Fishery management investigations. - a study of the upper Green River fishery, Sublette County, Wyoming (1975-1979). Completion Report. Wyoming Game and Fish Department, Fish Division, Cheyenne.
- Lowham, H. W. 1976. Techniques for estimating flow characteristics of Wyoming streams. U.S. Geological Survey Water Resources Investigations 76-112. 83p.
- Milhous, R.T., D.L. Wegner, and T. Waddle. 1984. User's guide to the physical habitat simulation system. Instream Flow Paper 11, FWS/OBS-81/43, U.S. Fish and Wildlife Service, Fort Collins, Colorado.
- Milhous, R.T., M.A. Updike, and D.M. Schneider. 1989. Physical habitat simulation system reference manual - version II. Instream Flow Information Paper No. 26. U.S. Fish and Wildlife Service, Biol. Rep 89(16).
- Miller, D.D. 1977. Comprehensive survey of the Bear River drainage. Wyoming Game and Fish, Administrative Report.

- Needham, P., J. Moffett, and D. Slater. 1945. Fluctuations in wild brown trout populations in Convict Creek, California. *Journal of Wildlife Management* 9:9-25.
- Nehring, R. 1979. Evaluation of instream flow methods and determination of water quantity needs for streams in the state of Colorado. Colorado Division of Wildlife, Fort Collins.
- Nehring, B.R. and R.M. Anderson. 1993. Determination of population-limiting critical salmonid habitats in Colorado streams using the Physical Habitat Simulation System. *Rivers* 4:1-19.
- Reimers, N. 1957. Some aspects of the relation between stream foods and trout survival. *California Fish and Game* 43:43-69.
- Reiser, D.W., T.A. Wesche, and C. Estes. 1989. Status of instream flow legislation and practices in North America. *Fisheries* 14(2):22-28.
- Remmick, R. 1981. A survey of native cutthroat populations and associated stream habitats in the Bridger-Teton National Forest. Wyoming Game and Fish Department, Administrative Report.
- Remmick, R. and N.A. Binns. 1987. Effect of drainage wide habitat management on Bear River Cutthroat trout (*Salmo clarki utah*) populations in the Thomas Fork drainage, Wyoming. Wyoming Game and Fish Department, Administrative Report.
- Remmick, R., K. Nelson, G. Walker, and J. Henderson. 1994. Bonneville cutthroat trout inter-agency five year management plan (1993-1997).
- Rosgen, D. 1985. A stream classification system. IN: *Riparian Ecosystems and Their Management; Reconciling Conflicting Uses*. Proceedings of the First North American Riparian Conference, April 16-18, Tucson, Arizona. GTR-RM120, pp. 91-95.
- WGFD. 1977. Current Status and Inventory of Wildlife in Wyoming 133 p

Appendix 1. Reach weighting used for PHABSIM Analysis

| Transect | Length | Weight | Percent | Habitat Type |
|----------|--------|--------|---------|---------------------|
| 0.0 | 9.4 | 0.50 | 5.2 | Riffle/Control/IFG1 |
| 18.9 | 20.8 | 0.50 | 11.4 | Pool/Run |
| 41.6 | 25.4 | 0.50 | 13.9 | Pool |
| 69.6 | 27.8 | 0.50 | 15.2 | Riffle/Control/IFG1 |
| 97.3 | 38.1 | 0.70 | 20.8 | Riffle/Run |
| 132.0 | 13.1 | 0.15 | 7.2 | Riffle/Control/IFG1 |
| 150.0 | 18.0 | 0.50 | 9.8 | Pool |
| 155.4 | 24.7 | 0.80 | 13.5 | Pool |
| 182.9 | 5.5 | 0.50 | 3.0 | Pool/Run |

Appendix 2 Spawning suitability index data used in PHABSIM analysis. Spawning index data were developed by WGFD from 1994 observations in Huff Creek.

| Spawning | Velocity | Weight | Depth | Weight | Substrate | Weight |
|----------|----------|--------|--------|--------|-----------|--------|
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 0.10 | 0.00 | 0.10 | 0.03 | 4.10 | 0.00 |
| | 0.20 | 0.01 | 0.15 | 0.08 | 4.20 | 1.00 |
| | 0.32 | 0.02 | 0.20 | 0.15 | 5.70 | 1.00 |
| | 0.45 | 0.03 | 0.25 | 0.30 | 5.80 | 0.00 |
| | 0.60 | 0.06 | 0.30 | 0.51 | 100.00 | 0.00 |
| | 0.76 | 0.11 | 0.35 | 0.70 | | |
| | 0.91 | 0.19 | 0.40 | 0.90 | | |
| | 1.01 | 0.25 | 0.45 | 1.00 | | |
| | 1.10 | 0.32 | 0.50 | 1.00 | | |
| | 1.22 | 0.44 | 0.55 | 0.82 | | |
| | 1.32 | 0.54 | 0.60 | 0.64 | | |
| | 1.41 | 0.64 | 0.65 | 0.41 | | |
| | 1.50 | 0.74 | 0.70 | 0.23 | | |
| | 1.60 | 0.83 | 0.75 | 0.12 | | |
| | 1.72 | 0.93 | 0.80 | 0.05 | | |
| | 1.81 | 0.98 | 1.00 | 0.01 | | |
| | 1.91 | 1.00 | 1.50 | 0.00 | | |
| | 1.97 | 1.00 | 100.00 | 0.00 | | |
| | 2.09 | 0.96 | | | | |
| | 2.19 | 0.91 | | | | |
| | 2.31 | 0.80 | | | | |
| | 4.41 | 0.71 | | | | |
| | 2.50 | 0.60 | | | | |
| | 2.62 | 0.47 | | | | |
| | 2.72 | 0.38 | | | | |
| | 3.20 | 0.00 | | | | |
| | 100.00 | 0.00 | | | | |